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THE USE OF MORPHOMETRIC CHARACTERISTICS FOR THE RECOGNITION OF SPECIES AMONG GONIOSOMATINE HARVESTMEN (ARACHNIDA, OPILIONES, GONYLEPTIDAE)

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ABSTRACT. Morphometric data from males of six species of *Goniosoma* are presented and their importance in characterization and recognition of the species is discussed. Data presented show that it is important to use intraspecific variation during descriptions of these harvestmen.

Harvestmen (Arachnida, Opiliones) are worldwide in distribution. Most papers on harvestmen treat taxonomic aspects. Biological, ecological and behavioral surveys are somewhat rare, especially those dealing with developmental characterization. Most taxonomic papers that describe species present single measurements of body structures. This is, in part, because many species are known by only a single specimen. As discussed by McGhee (1977), the structures may vary among specimens of different populations or even of the same population. Gnaspini (1995) also showed that measurements vary due to developmental differences. In the present paper, variation among different species is analyzed and discussed. The main goal of this paper is to show the importance of taking into account these aspects when diagnosing and describing species of harvestmen. Toward this goal, the morphometric characterization of adults of six different species of *Goniosoma* is presented and discussed.

METHODS

The species treated here were collected during a study focusing on the cavernicolous species *Goniosoma spelaeum* (Mello-Leitão 1933) in the Ribeira Valley, São Paulo State, southeastern Brazil (Gnaspini 1993). The species included in this study were collected in caves in São Paulo State and/or in the neighborhood of the study area, as follows: *Goniosoma* sp. 1 aff. *badium* - caves near Curitiba, Paraná State; *Goniosoma* sp. 2 aff. *badium* - Guaricana Dam, near Curitiba, Paraná State; *Goniosoma longipes* (Roewer 1931) - Caves near Ipeúna, São Paulo State; *Goniosoma proximum* (Mello-Leitão 1933) - forest in the Ribeira Valley (except when in two specific caves within the distribution of *G. spelaeum* - see Gnaspini 1996), São Paulo State; *Goniosoma spelaeum* (Mello-Leitão 1933) - caves in the Ribeira Valley, São Paulo State; *Goniosoma varium* Perty 1833 - forest and inside the first 0.5 m of caves in the Ribeira Valley, São Paulo State.

Collected animals were fixed in 40% ethyl alcohol and, after some hours, transferred to flasks with 70% alcohol. This procedure avoided hardening of the specimens, especially their leg articulations, and facilitated easy measurements. A series of voucher specimens of all species treated herein is deposited in the Museu de Zoologia da Universidade de São Paulo (MZSP).

Morphometrical and meristic characteristics were observed with a Wild M5A stereomicroscope. The characteristics used in the analysis were the number of tarsal segments and the measurement of body width (maximum width of dorsal scutum), body length (length of the dorsal scutum), total length of the pedipalp and of the walking legs.

The raw data have been statistically analyzed using the Möls' method (Möls 1987 *apud* Neet 1993; Gnaspini 1995), which tests if two given sets have their values homogeneous or heterogeneous, i.e., if they should be considered the same or different from each other. Neet (1993) provided an example of use with spiders and an algorithm for the test. Briefly described, the test first orders the values analyzed and then groups them by values

Table 1.—Results of the Möls's test for each pair of species studied, for body length measurements taken in adult males of *Goniosoma*. "+" = "securely heterogeneous" ($\alpha < 0.01$), "±" = "probably heterogeneous" ($0.01 < \alpha < 0.05$), "−" = "possibly homogeneous" ($\alpha > 0.05$). The value of α is given between parentheses following the respective symbol.

	G. varium ($n = 4$)	*G. spelaeum* ($n = 8$)	*G. proximum* ($n = 10$)	*G. longipes* ($n = 5$)	*G.* sp. 2 aff. *badium* ($n = 8$)
G. sp. 1 aff. *badium* ($n = 8$)	−(2.13)	−(0.685)	−(0.575)	±(0.041)	−(1.46)
G. sp. 2 aff. *badium*	−(2.78)	−(1.05)	+(0.002)	−(0.317)	
G. longipes	−(0.709)	−(0.167)	−(2.31)		
G. proximum	−(0.079)	−(0.105)			
G. spelaeum	−(3.23)				

as if to prepare a graph of distribution. Following this the data are treated as two curves of distribution that may overlap. The percentage of overlap is represented by α. If α is smaller than 5%, the test considers the distribution heterogeneous, and provides a limit value. Individuals with values smaller than this limit are considered as part of a group, and those with larger values are part of a second group. A series of these pair-wise comparisons then determines the similarities of species.

RESULTS

The number of tarsal segments showed mostly the same ranges among the species studied (global range of 8–12 segments in Leg I, 14–25 in Leg II, 9–14 in leg III, and 9–15 in leg IV), although *G. spelaum* showed the larger values and *G. varium* showed the smaller values. Because the variation was not statistically significant, the number of tarsal segments proved not to be useful in the recognition among species.

Möls' test of body width measurements showed that this feature is not also useful in distinguishing the species. The resulting α ranged from 0.154 to 27.55. Figure 1 shows large overlaps among the measurements of the species.

On the other hand, Möls' analyses (Tables 1–6) showed that body length, the length of legs I–IV, and palpal length are useful measurements in distinguishing *Goniosoma* species. Figure 1 shows graphically the differences in the means and variances of these measurements. However, the lengths of body and of palp are useful only for given pairs of species. For example, from Table 6 (palpal length), α (interval of significance of the test) is mostly larger than 5% for the pairs of species analyzed, being coded as a "-" in the table. This means that the differences are not statistically significant. For pair *G. spelaeum* - *G. longipes*, α is smaller than 5%, being statistically significant, and coded as a "±" in the table. Finally, α is smaller than 1%, being coded as a "+" in the table, showing that the differences are highly significant for

Table 2.—Results of the Möls's test for each pair of species studied, for leg I length measurements taken in adult males of *Goniosoma*. "+" = "securely heterogeneous" ($\alpha < 0.01$), "±" = "probably heterogeneous" ($0.01 < \alpha < 0.05$), "−" = "possibly homogeneous" ($\alpha > 0.05$). The value of α is given between parentheses following the respective symbol.

	G. varium ($n = 4$)	*G. spelaeum* ($n = 8$)	*G. proximum* ($n = 10$)	*G. longipes* ($n = 5$)	*G.* sp. 2 aff. *badium* ($n = 8$)
G. sp. 1 aff. *badium* ($n = 8$)	+(0.0002)	±(0.018)	+(0.0008)	+(0.0015)	+(0.007)
G. sp. 2 aff. *badium*	+(0.0018)	−(19.18)	−(44.68)	+(0.0048)	
G. longipes	−(0.407)	+(0.0012)	+(0.00002)		
G. proximum	+(0.000007)	−(2.76)			
G. spelaeum	+(0.0008)				

Table 3.—Results of the Möls's test for each pair of species studied, for leg II length measurements taken in adult males of *Goniosoma*. "+" = "securely heterogeneous" ($\alpha < 0.01$), "±" = "probably heterogeneous" ($0.01 < \alpha < 0.05$), "−" = "possibly homogeneous" ($\alpha > 0.05$). The value of α is given between parentheses following the respective symbol.

	G. varium ($n = 4$)	*G. spelaeum* ($n = 8$)	*G. proximum* ($n = 10$)	*G. longipes* ($n = 5$)	*G.* sp. 2 aff. *badium* ($n = 8$)
G. sp. 1 aff. *badium* ($n = 8$)	±(0.037)	−(0.075)	+(0.0000004)	+(0.0007)	±(0.019)
G. sp. 2 aff. *badium*	−(0.059)	−(8.38)	−(4.08)	+(0.0036)	
G. longipes	−(1.12)	+(0.0069)	+(0.000001)		
G. proximum	+(0.00002)	−(0.134)			
G. spelaeum	±(0.054)				

pairs *G. proximum* - *G.* sp. 2 aff. *badium*, *G. proximum* - *G. spelaeum*, and *G. spelaeum* - *G. varium*.

When values of length of legs I, II, III and IV do not allow recognition, other structures can be used. One good example is the case of *G.* sp. 2 aff. *badium* and *G. proximum*, which can be easily distinguished by the length of the body and especially of the palp.

The only two pairs of species which could not be statistically recognized using morphometrics were *G.* sp. 2 aff. *badium* and *G. spelaeum*, and *G. longipes* and *G. varium*. Therefore, other characters should be used, such as color, as treated below.

DISCUSSION

These data show that there are morphometric, morphological and meristic variations between and within species of harvestmen, as previously discussed by McGhee (1977) and Gnaspini (1995). These intraspecific variations may be even very large, and may be due either to variation within the same developmental stage or between stages. In addition, adding measurements of single specimens during descriptions (even when series are available) does not allow precise species recognition. For instance, if a given specimen of the same species is checked against measurements of only one described specimen, it may not fit, and would not be recognized as such species. However, if a range of variation was given, it would probably fit.

In addition, data also show that the range of variation may help identify species. Of course, genitalia characterization and color patterns can also help distinguish species from each other. Sometimes, they do so alone; however, in other cases they are conservative and misleading.

In her unpublished revision of the genus *Goniosoma*, Stefanini- Jim (1985, 1995, pers. comm.) proposed synonymizing several species under *G. badium*, due to the conservative shape of their penis. She also considers *G. spelaeum* to belong in a 'badium-group', and possibly being synonymous with *G. badium*, again because of the similar penis. She

Table 4.—Results of the Möls's test for each pair of species studied, for leg III length measurements taken in adult males of *Goniosoma*. "+" = "securely heterogeneous" ($\alpha < 0.01$), "±" = "probably heterogeneous" ($0.01 < \alpha < 0.05$), "−" = "possibly homogeneous" ($\alpha > 0.05$). The value of α is given between parentheses following the respective symbol.

	G. varium ($n = 4$)	*G. spelaeum* ($n = 8$)	*G. proximum* ($n = 10$)	*G. longipes* ($n = 5$)	*G.* sp. 2 aff. *badium* ($n = 8$)
G. sp. 1 aff. *badium* ($n = 8$)	+(0.0052)	±(0.011)	+(0.0003)	−(0.069)	+(0.0027)
G. sp. 2 aff. *badium*	+(0.0072)	−(30.80)	−(99.45)	±(0.018)	
G. longipes	−(0.149)	+(0.0041)	+(0.0002)		
G. proximum	+(0.00004)	−(4.37)			
G. spelaeum	+(0.0015)				

Table 5.—Results of the Möls's test for each pair of species studied, for leg IV length measurements taken in adult males of *Goniosoma*. "+" = "securely heterogeneous" ($\alpha < 0.01$), "±" = "probably heterogeneous" ($0.01 < \alpha < 0.05$), "−" = "possibly homogeneous" ($\alpha > 0.05$). The value of α is given between parentheses following the respective symbol.

	G. varium ($n = 4$)	*G. spelaeum* ($n = 8$)	*G. proximum* ($n = 10$)	*G. longipes* ($n = 5$)	*G.* sp. 2 aff. *badium* ($n = 8$)
G. sp. 1 aff. *badium* ($n = 8$)	+(0.0003)	±(0.038)	+(0.0008)	±(0.023)	+(0.0001)
G. sp. 2 aff. *badium*	+(0.0002)	−(1.06)	−(3.35)	+(0.0025)	
G. longipes	−(0.716)	+(0.0038)	+(0.0002)		
G. proximum	+(0.00002)	±(0.014)			
G. spelaeum	+(0.0007)				

also identified the two species, treated herein as *G.* sp. 1 and 2 aff. *badium*, as belonging to *G. badium*. However, the morphometric data available showed that these species can be separated. Moreover, they differ in color, both in nature and preserved specimens. *Goniosoma spelaeum* and *G. badium* (*sensu* Stefanini-Jim) are yellowish-brown (however, the latter has very contrasting dark brown legs), whereas the others are darker - *G.* sp. 2 aff. *badium* being dark brown, and *G.* sp. 1 aff. *badium* being dark greenish-brown. *Goniosoma* sp. 2 aff. *badium* has the pleura of articulations between coxae and trocanters pink-colored, whereas the others are white. In addition, this species and *G. badium* (*sensu* Stefanini-Jim) have a series of internal spines on femur IV from base to the medial portion, whereas the others have from one to three medial internal spines on femur IV.

In conclusion, this paper is intended to show that morphometrical variation is important when describing harvestmen and can provide useful information and avoid misidentification of species. Therefore, although it would take a long time to be done, I suggest that systematists include ranges of variation in their descriptions of new species. These would give a holistic understanding of the species being described, and a larger number of characters to be used in species recognition.

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Table 6.—Results of the Möls's test for each pair of species studied, for palp length measurements taken in adult males of *Goniosoma*. "+" = "securely heterogeneous" ($\alpha < 0.01$), "±" = "probably heterogeneous" ($0.01 < \alpha < 0.05$), "−" = "possibly homogeneous" ($\alpha > 0.05$). The value of α is given between parentheses following the respective symbol.

	G. varium ($n = 4$)	*G. spelaeum* ($n = 8$)	*G. proximum* ($n = 10$)	*G. longipes* ($n = 5$)	*G.* sp. 2 aff. *badium* ($n = 8$)
G. sp. 1 aff. *badium* ($n = 8$)	−(0.144)	−(0.078)	−(1.56)	−(1.30)	−(2.07)
G. sp. 2 aff. *badium*	−(0.076)	−(2.12)	+(0.0007)	−(1.05)	
G. longipes	−(0.115)	±(0.042)	−(5.56)		
G. proximum	−(0.938)	+(0.000004)			
G. spelaeum	+(0.0050)				

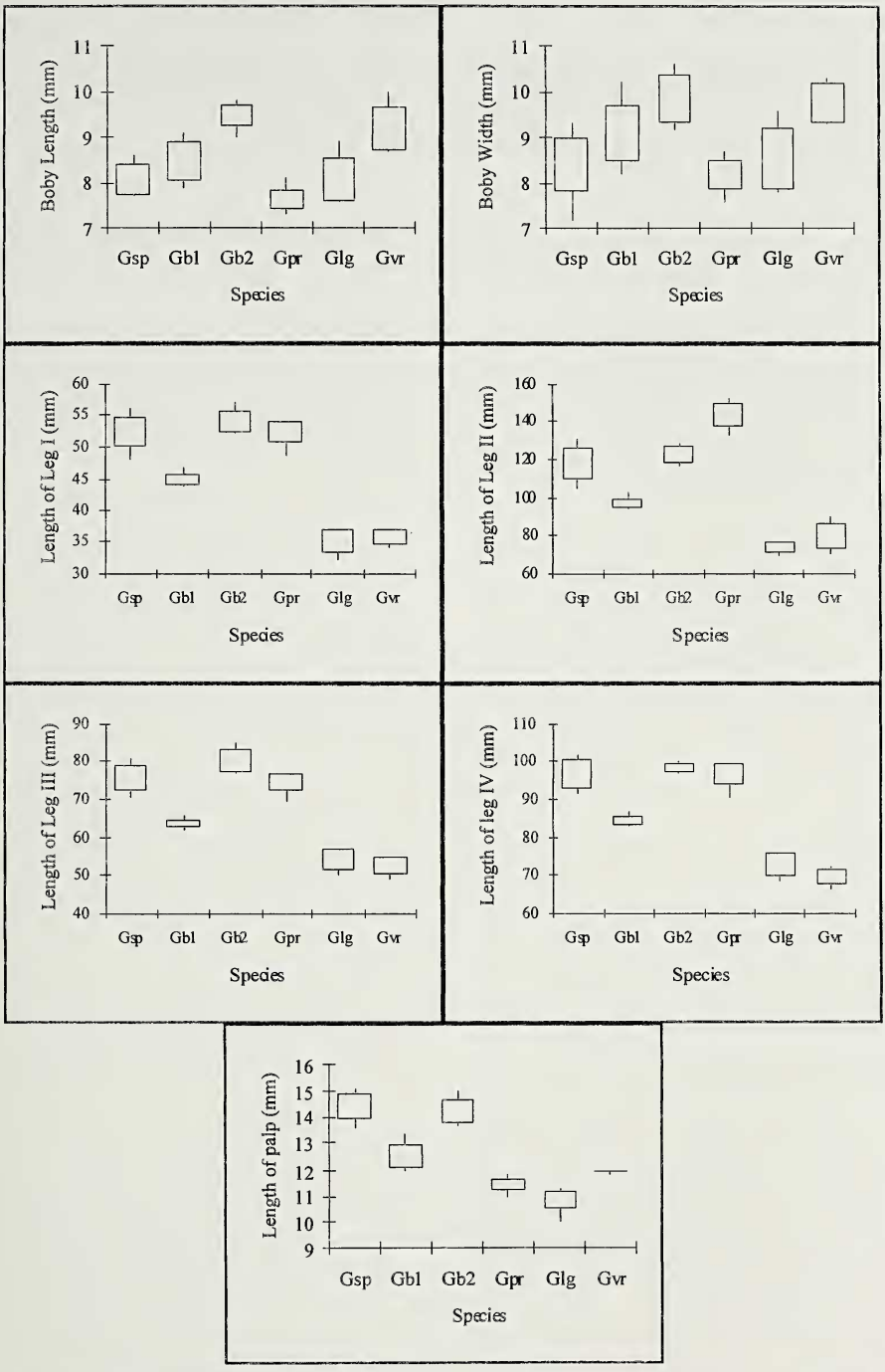

Figure 1.—Mean ± standard deviation (rectangles) and amplitude of variation (lines) for the morphometric measurements taken in adult males of *Goniosoma spelaeum* (Gsp, n = 8), *G.* sp. 1 aff. *badium* (Gb1, n = 8), *G.* sp. 2 aff. *badium* (Gb2, n = 5), *G. proximum* (Gpr, n = 10), *G. longipes* (Glg, n = 5), and *G. varium* (Gvr, n = 4). Values are in millimeters.

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